79. (New) An apparatus as in 76 wherein the equalizer is a decision feedback equalizer and the decoder is a trellis decoder.

80. (New) A method of receiving data from an optical channel the method comprising:

accepting a multilevel optical signal from the channel into an optical to electrical converter;

converting the multilevel signal into an analog electrical signal;

converting the analog electrical signal into a digital signal; and

decoding the digital signal in a decoder.

REMARKS

The specification has been amended to improve clarity and to correct minor typographic errors. Claims 17, 20, 21, 24, 32, 33, 38, 40, 41, 42, 44 and 45 have been amended to improve clarity. Claims 49 through 80 are new. Claims 1 through 80 are pending in the application. No new matter has been added. Applicant requests entering of the amended claims, additional claims, in consideration of the application.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**<u>Version with markings to show changes made</u>**."

Application No. 09/765,014

If there is any difficulty with the present application or the present amendment, applicant would appreciate a phone call to the attorney listed below.

Respectfully submitted,

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Application No. 09/765,014

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the specification:

On page 1, paragraph 4, line 25, change the heading ~~SUMMARY OF INVENTION~~ **SUMMARY OF EMBODIMENTS OF THE INVENTION**

Please insert the following paragraphs at page 1, line 34 as follows:

In another aspect of the invention an apparatus for receiving data from a fiber optic channel is disclosed. The apparatus comprises an electrical to optical converter that receives an optical signal and converts the optical signal into an analog signal. A decoder accepts the analog signal and converts it into a digital signal. A decoder then accepts and decodes the digital signal producing data. The decoder may be a trellis decoder, and embodiments may incorporate a decision feedback equalizer.

Additionally methods corresponding to functions performed by the apparatuses may form embodiments of the invention.

Please replace the paragraph beginning at page 6, paragraph 3, line 20, with the following rewritten paragraph:

Figure 3 is a block diagram illustrating the fiber optic transmitter 200 according to an embodiment of the current invention. Detail of the transmitter 200 is illustrated in Figure 3. The trellis encoder 323 accepts a group of R bits from the data source 202. The trellis encoder 305 is a rate M/(M+1) convolutional coder of the R bits which are input to the rate **M/(M+1)** ~~m/(M+1)~~ encoder. R-M bits will be unencoded and M bits will be encoded. The output of the convolutional coder 305 comprises (M+1) bits. The R-M unencoded bits and the M + 1 coded bits, which are output from the convolutional coder 305 are provided to a subset mapper 307. The subset mapper 307

maps the received bits into a series of multilevel symbols 309, for example, PAM 5. The combination of convolutional coder 305 and the R-M unencoded bits comprises a trellis encoder 323. The pulse amplitude modulated signals A_1 through A_N have 5 levels, but may have any number of amplitude levels, depending on the pulse amplitude modulation scheme chosen.

Please replace the paragraph beginning at page 5, paragraph 4, line 32 through page 6, line 10, with the following rewritten paragraph:

In Figure 3 multilevel symbols 309 are provided to a Tomlinson Precoder. For example in a 10 gigabit per second ~~(GPS)~~ **(Gbls)** transmission system implemented using a five level pulse amplitude modulation - 5 level (PAM-5) transmission scheme. The baud rate necessary to achieve a 10 GPS transmission is reduced to five gigabaud because each PAM-5 symbol can represent ~~five different values~~ **two bits**.

Page 8, paragraph 1, line 11, replace the paragraph with the following rewritten paragraph:

Difficulties can be encountered because at frequencies where the channel has a lot of attenuation, the precoder will have a lot of gain to compensate for the attenuation. At such frequencies, the precoder may become unstable. Therefore, in order to stabilize the precoder and to limit the amplitude of the signal out of the precoder, a signal V_n represented by arrow 403 is added to the summation unit 405A. $V_n = K_n \times M$ where M is the number of levels being transmitted on the channel. In the present embodiment, which uses PAM-5, M has a value of 5. ~~M is essentially the maximum number of levels desired at the output.~~ Once the output signal of the precoder, V_n is computed, if the signal exceeds certain limits then V_n is subtracted from the signal Y_n and K_n is the smallest integer that brings the output Y_n back

into the desired range. There is always a value for K_n that will meet this condition. M is essentially the maximum allowable range of the output of the precoder. Depending on the value of Y_n there is a unique integer value K_n that will bring the output of the precoder back within the range M. This is the basis of Tomlinson Harashima Precoding (THP). In other words, the THP does the inverse channel characteristic filtering then modifies the input to the summation unit by adding an integral multiple of M which ~~at~~ **makes** the output ~~is~~ bounded. The signal V_n is added to the input. The output of the channel sees a quantity equal to X_n plus V_n. In other words, the number of levels appearing at the receiver has been expanded. Therefore, the slicer in the receiver must be able to distinguish X_n + V_n levels instead of just being able to distinguish X_n levels. One price for doing this type of equalization is the increase of the number of levels in the constellation at the receiver. Therefore, all that needs to be done in the receiver to recover the original PAM-5 levels is to implement a wrap-around scheme such that the excess levels are wrapped around into the original PAM-5 levels. The wrap around is illustrated in Figure 4A.

Please replace the paragraph beginning at page 11, paragraph 1, line 5, with the following rewritten paragraph:

The analog to digital converters (A/D) 509 are timed by a clock provided by the timing recovery circuit 515. Each A/D converter, however, receives its own phase of the clock in order to sample successive values using successive A/D converters. Because the values received by the A/D converters are sampled using a clock having different phases, retiming of the signals is necessary in order to create a synchronized parallel value. The retiming of the A/D samples takes place in retiming block 511. Retiming block 511 essentially comprises a clocked register circuit or equivalent. By interleaving N A/D converters in the analog to digital block 509, the clock rate

of each individual converter can be reduced by a factor of N (over the use of a single converter). Without the interleaving of analog to digital converters 509 it may be difficult or impossible to fabricate an analog to digital converter, which could sample the input at a high enough rate, in order not to lose any successive values in the input data stream. By interleaving the A/D converters the necessity of using very high speed circuit technologies, such as gallium arsenide ~~arsenido~~ or indium phosphide may be avoided.

Please replace the paragraph beginning at page 11, paragraph 3, line 25, with the following rewritten paragraph:

The output of the fine AGC block 513 is coupled into ~~an N-dimensional~~ **K-way interleaved L-dimensional** trellis decoder ~~519. An N-dimensional trellis decoder includes N trellis decoders. The number~~**. Commonly the produce K+N will be equal to an integer multiple of N. In other words, K_L - rN where r is an integer greater or equal to 1. The number K** of trellis decoders will vary depending on a variety of implementation details. The N-dimensional trellis decoder 519 decodes the symbols accepted from the fine AGC module 513 and converts them into digital data values.

In the Claims:

17. (Amended) The method of claim 11 wherein converting the plurality of digital multilevel symbols into a plurality of analog multilevel symbols further comprises:

accepting the plurality **of** digital multilevel symbols into a subset mapper; and

forming a plurality of mapped analog multilevel symbols from the plurality of digital multilevel symbols.

20. (Amended) The method as in claim 12 wherein equalizing the digital multilevel symbols to compensate for the laser and channel characteristics comprises:

characterizing the channel; and

using ~~applying~~ an inverse characterization of the channel to **modify** the digital multilevel symbols.

21. (Amended) The method as in claim 12 wherein equalizing the digital multilevel symbols to compensate for the laser and channel characteristics comprises:

characterizing the channel; and

using ~~applying~~ an inverse characterization of the channel to **modify** the plurality of analog multilevel symbols.

24. (Amended) A method of receiving data from an optical channel the method comprising:

accepting a multilevel **optical** signal from the channel into an optical to electrical converter;

converting the multilevel signal into an analog electrical signal;

converting the analog electrical signal into a digital signal; and

decoding the digital signal in a trellis decoder.

32. (Amended) An apparatus for transmitting information on an optical channel ~~to~~ **the** apparatus comprising:

a trellis encoder for accepting digital information and producing digital multilevel signals;

a digital to analog converter that accepts the digital multilevel signals and produces analog multilevel signals; and

an analog signal to optical converter that converts the analog signal to an optical level for coupling into an optical channel.

33. (Amended) The apparatus of claim 32 further comprising an equalizer that accepts the digital multilevel signals and produces equalized digital multilevel signals prior to coupling into the digital to analog **converter**.

38. (Amended) An apparatus for concurrently transmitting a plurality of data signals over an optical channel, the apparatus comprising:

a plurality of trellis encoders that accept a plurality of data signals and ~~produce~~ **produces** a plurality of digital multilevel signals;

a converter that accepts ~~a~~ **the** plurality of digital multilevel signals and produce**s** a plurality of analog multilevel signals;

an optical source that receives the plurality of analog multilevel signals and produces a light output proportional to the level of successive analog multilevel signals for driving an optical channel.

40. (Amended) An apparatus as in claim 39 wherein the plurality of equalizers comprise ~~a plurality of~~ **at least one** Tomlinson-Harashima **precoder** ~~precoders~~.

41. (Amended) An apparatus as in claim 39 wherein ~~the plurality of~~ **at least one** dynamic limiting **precoder** ~~precoders~~.

42. (Amended) An apparatus for concurrently transmitting a plurality of data signals over an optical channel the apparatus comprising:

a plurality of trellis encoders that accept a plurality of data signals and produce a plurality of digital multilevel signals;

~~an analog to~~ **a** digital **to analog** converter that sequentially accepts the plurality of digital multilevel signals and produces a plurality of sequential analog multilevel signals;

an optical source that receives the plurality of analog multilevel signals for driving an optical channel.

44. (Amended) An apparatus as in claim 43 wherein the plurality of equalizers comprise ~~a plurality of~~ **at least one** Tomlinson-Harashima **precoder** ~~precoders~~.

45. (Amended) An apparatus as in claim 43 wherein the plurality of equalizers comprise ~~a plurality of~~ **at least one** dynamic limiting **precoder** ~~precoders~~.